



# **Earth Observations from Space:**

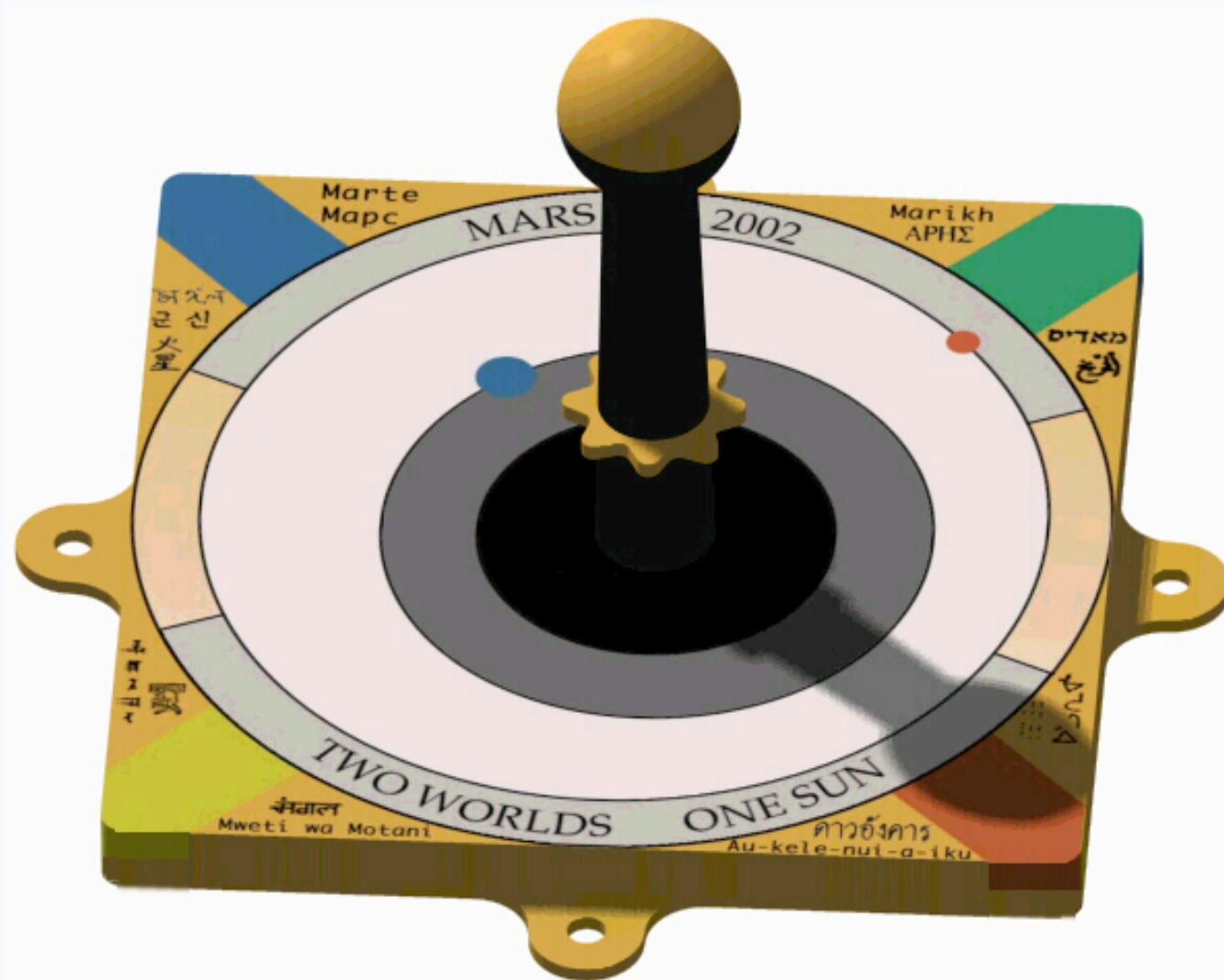
## **Scientific Accomplishments Before and at the Dawn of the Space Age**

**James Fleming, Colby College**

**We shall not cease from exploration,  
and the end of all our exploring  
will be to arrive where we started  
and know the place for the first time.  
-- T. S. Eliot**

Humans have long observed their environment as they sought for better, higher and more inclusive vantage points. This was true for individuals, coordinated networks, and remote observations from mountaintops, balloons, aircraft, and rockets. For over fifty years now, Earth-orbiting satellites have provided privileged perspectives and have supported the emergence of an integrated Earth system science that was not possible before. These observations have supported many fundamental scientific advances, greatly enhanced predictive and monitoring capabilities, and have been of immense social value. Satellite observations have literally transformed the way we view the planet and have provided unprecedented insight into how the Earth system functions. Today I will present historical perspectives on Earth observations before the formal launch of NASA's Earth System Science program. I'd like to say that NASA history is firmly rooted in all of human history—especially that history of aspiration, inspiration, discovery, and care for the environment.

# Gnomon or Sundial



The first humans to observe the Earth in a systematic way were... the first humans!  
A gnomon or sundial can reveal an amazing amount of information about Earth-Sky relations

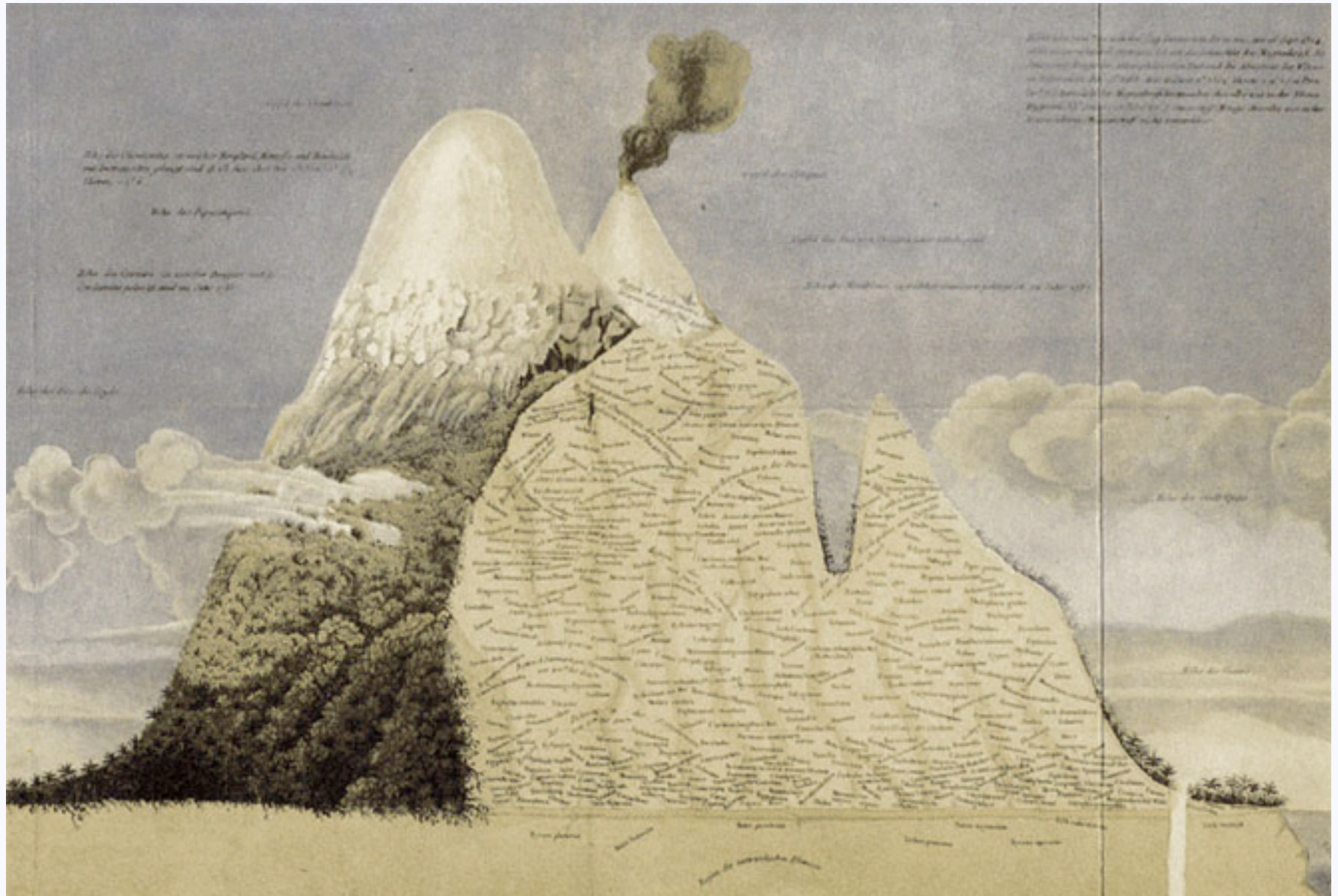
Temple of the Sun  
Teotihuacán, Mexico,  
50-200 CE



Temple of the Sun  
Machu Picchu, Peru,  
1430 CE



# A. von Humboldt, Chimborazo, 1805



## Pike's Peak Observatory, Signal Office, 1873



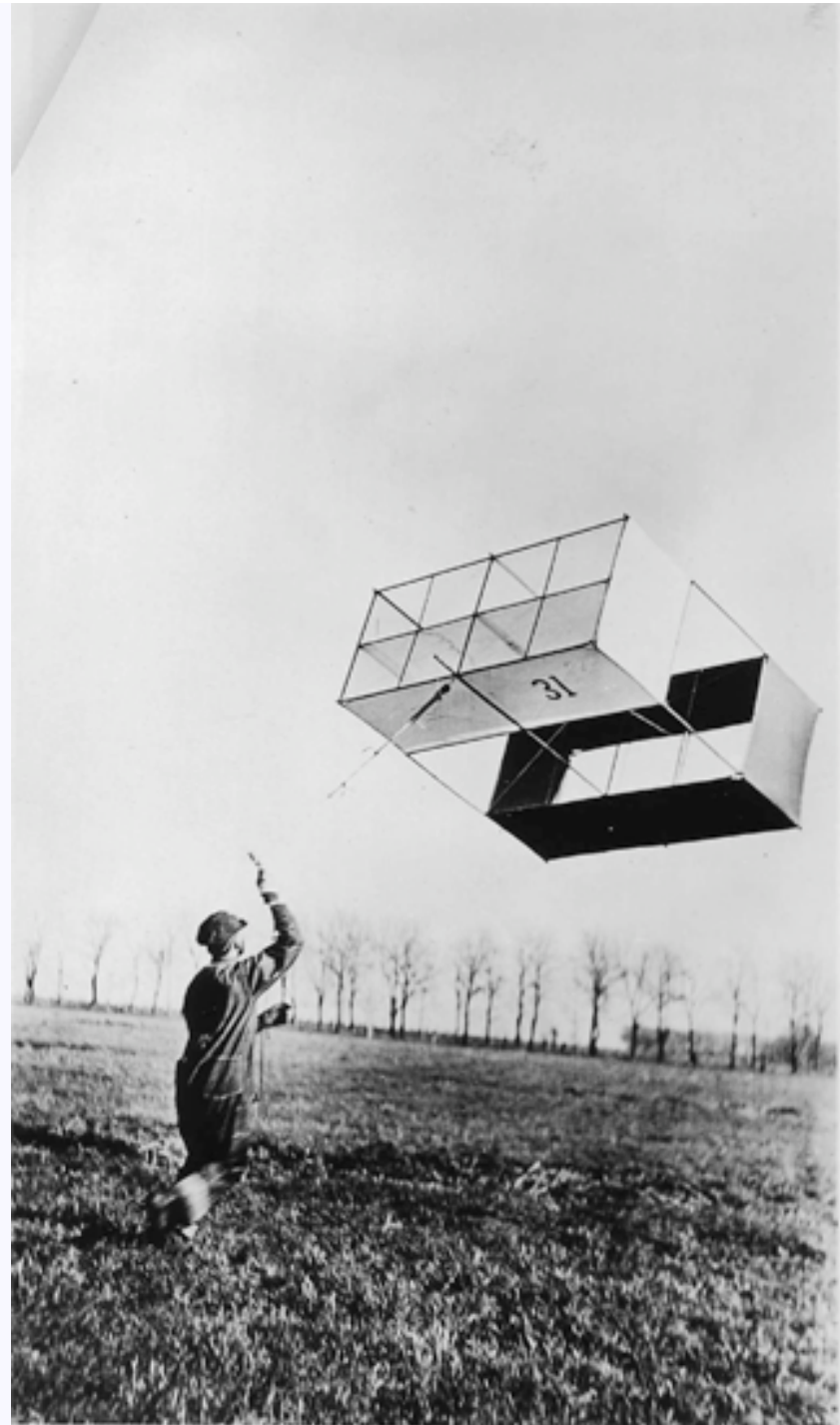


Sphinx  
Observatory  
Jungfrauoch  
Swiss Alps,  
1937 at the top  
of Europe

# Mauna Loa, opened in the mid-1950s



# Meteorological Kites, 1749-1933



Eiffel Tower, 1889,  
used for  
meteorological  
instrumentation  
since the wind flows  
through it.

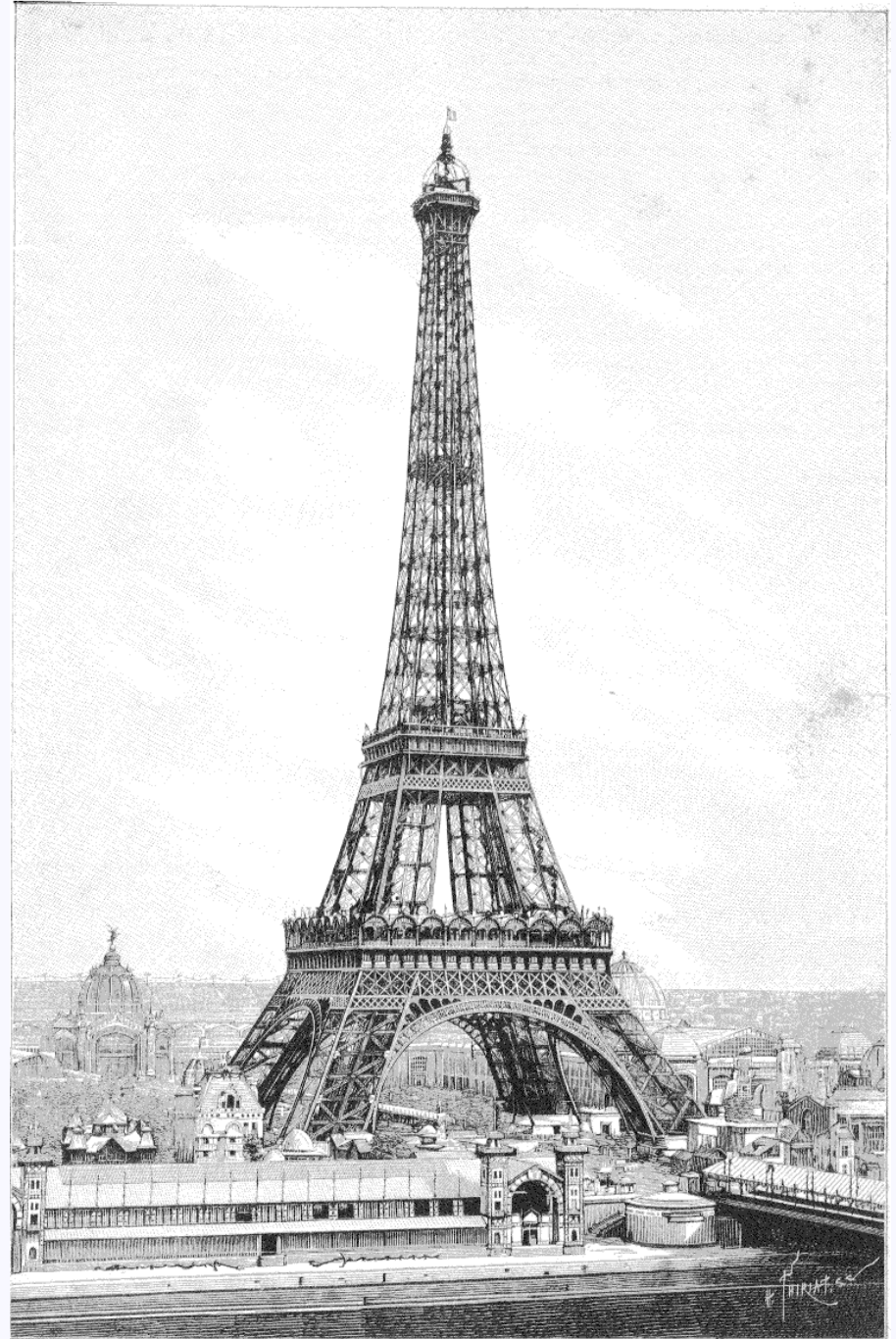


Fig. 3. — Exposition universelle de 1889. — La Tour Eiffel au Champ de Mars, à Paris.



Pilot balloon  
with theodolite  
tracker and  
electrical  
timer, 1917

**Radiosonde and  
ground tracking  
station,  
ca. 1936**

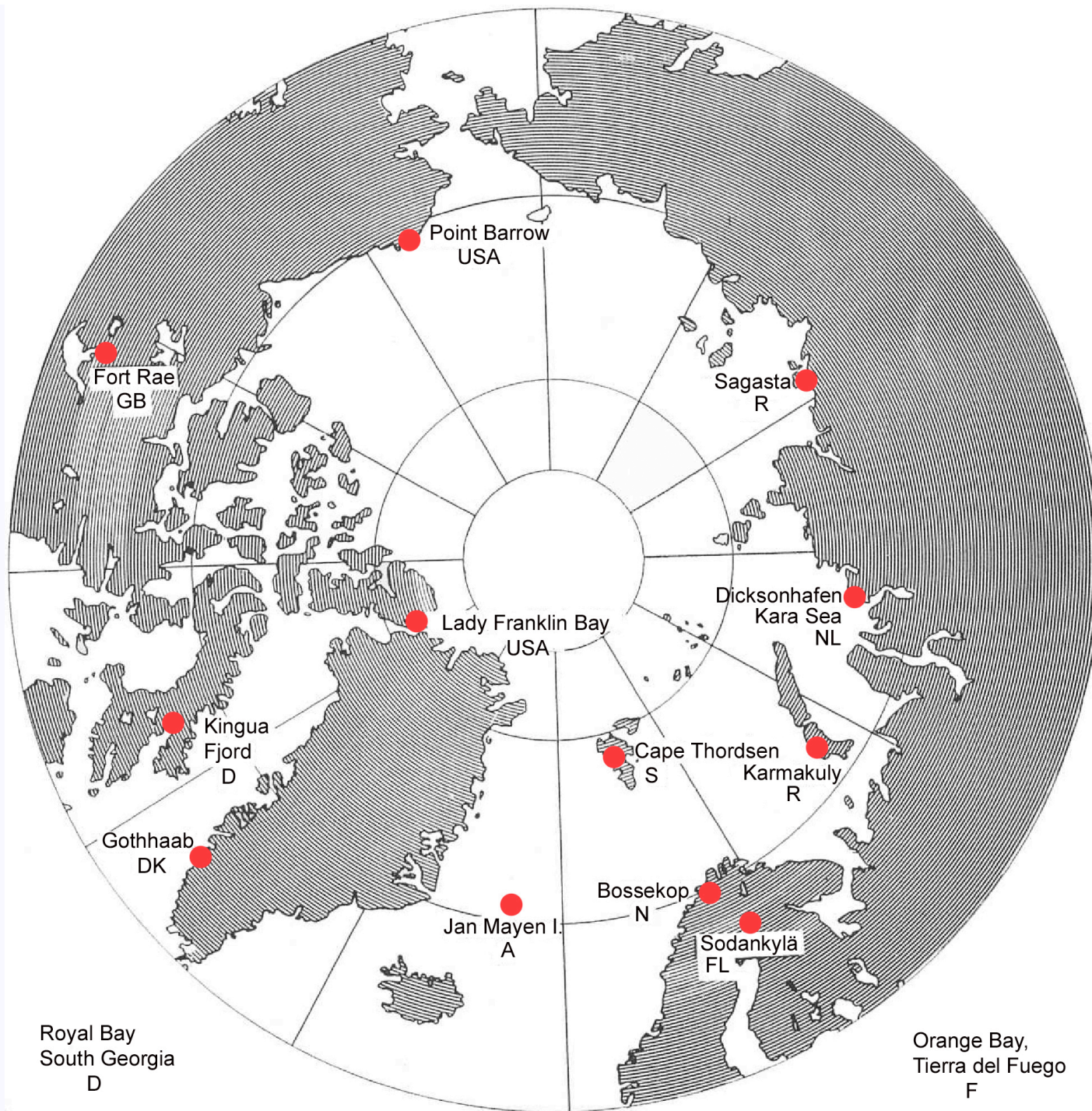


**Montgolfiere  
Balloon,  
1783,  
dawn of the  
aeronauts**



**Instrumented aircraft ca. 1930,  
with meteorograph under right wing**



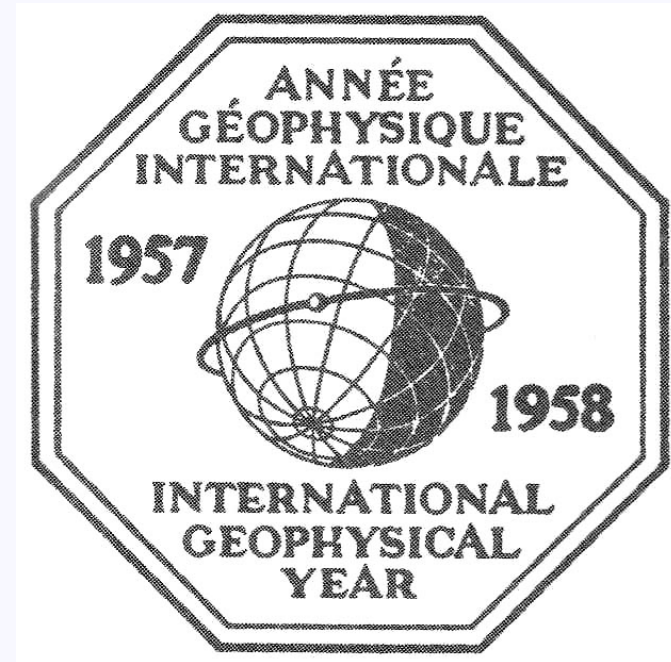


**International  
Polar Year  
Stations,  
1882-1883**  
involved 11  
nations in a  
coordinated  
effort to  
study  
atmospheric  
changes at  
the poles.

# IPY 2, radio transmitter for Simavik, W.C. Brown operating, 1932-1933



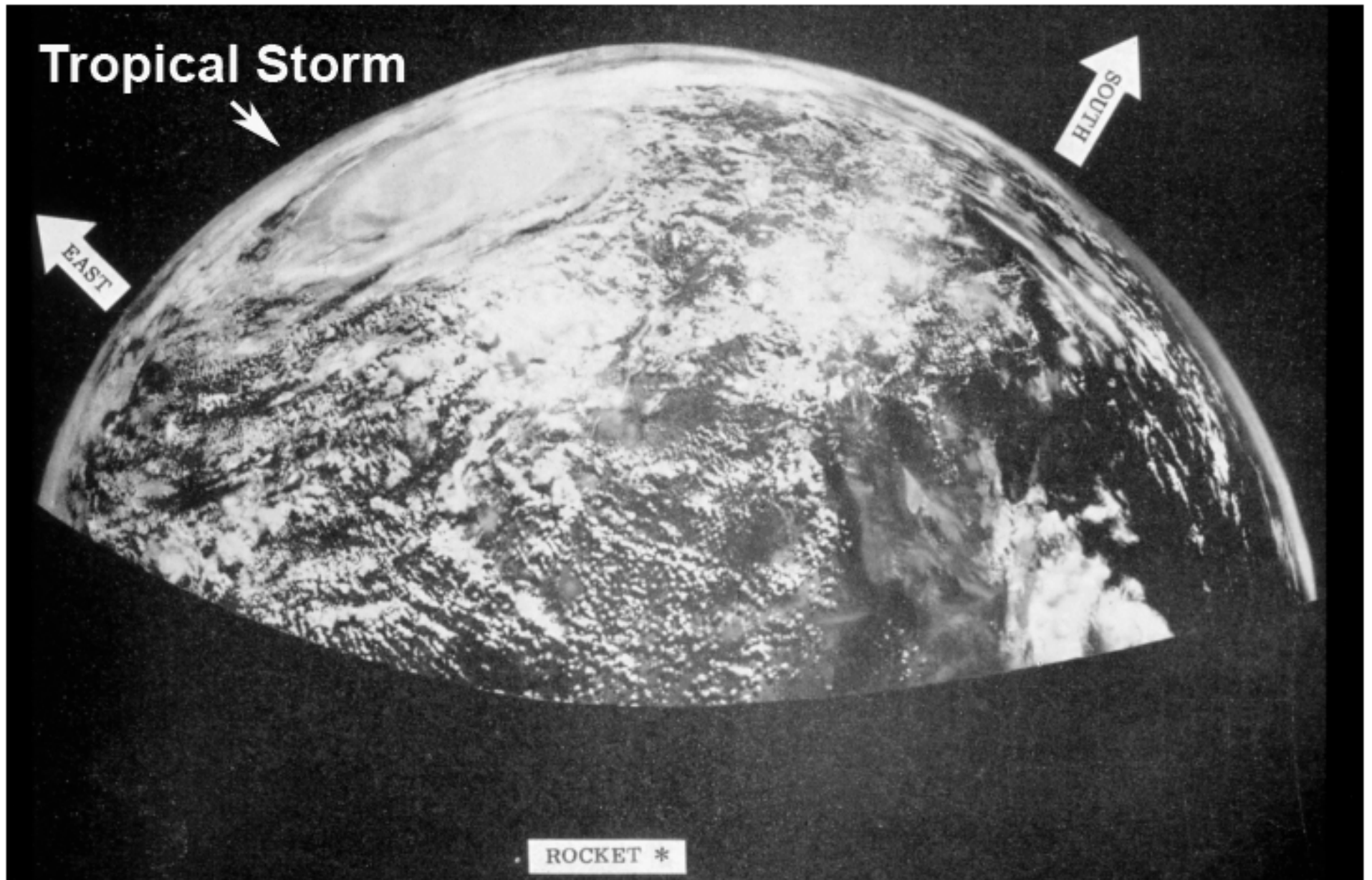
# IGY, 1957-1958



**The IGY symbol as adopted in 1955 and as used as a logo, emphasizing the influence of the sun on the Earth, scientific focus on Antarctica, and the hope that geophysical satellites would soon be placed in orbit.**

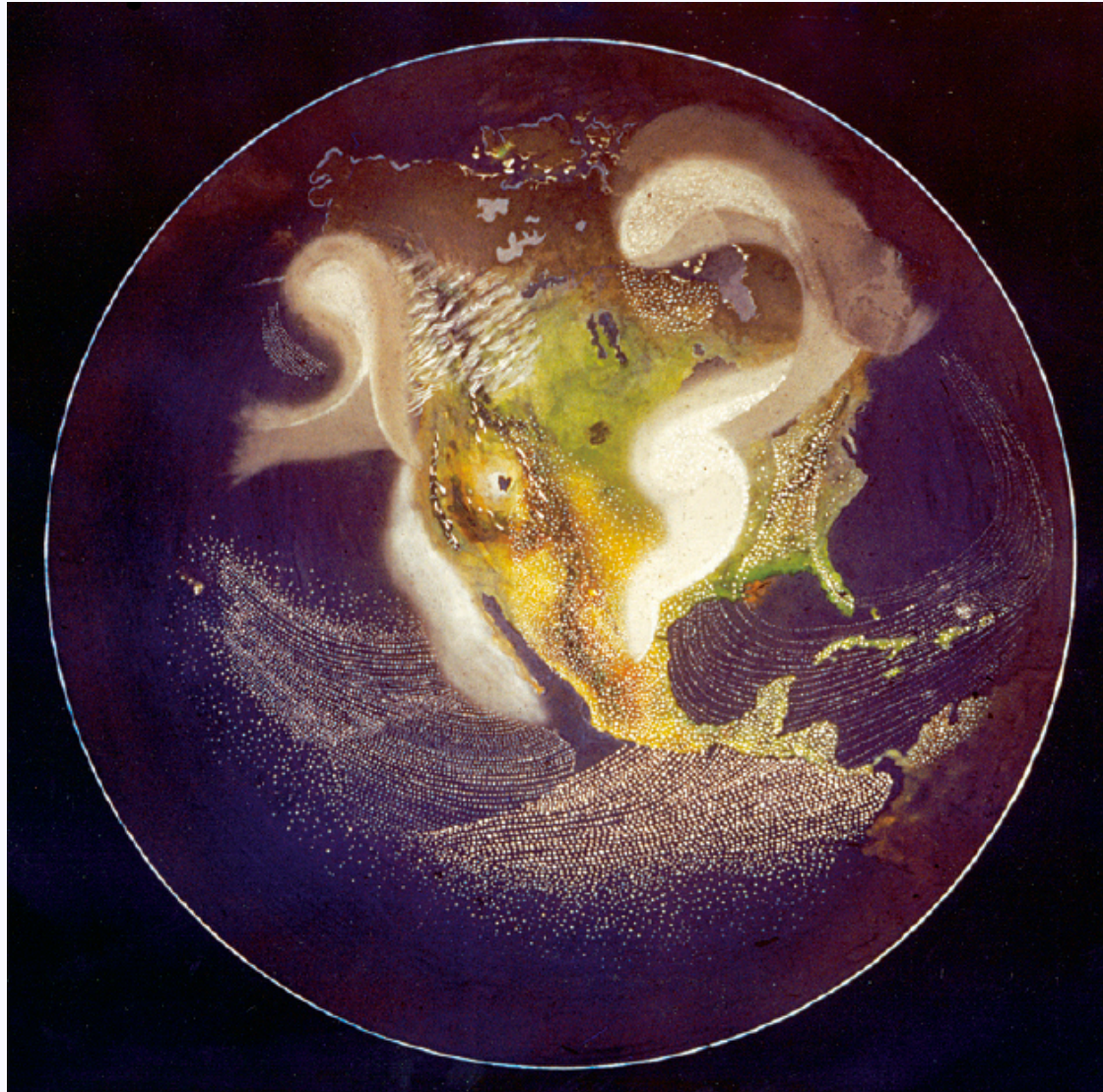
**Bumper V-2  
Cape Canaveral  
24 July 1950**





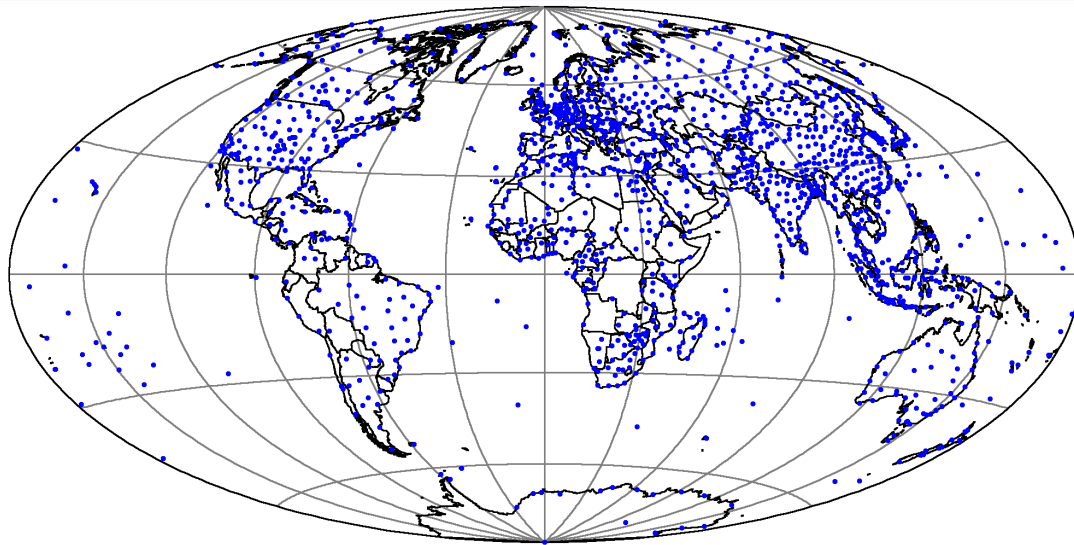
**Aerobee rocket image reveals tropical storm, 1954.**

**Artist's conception of Earth from space 1954,  
painting commissioned by Harry Wexler**

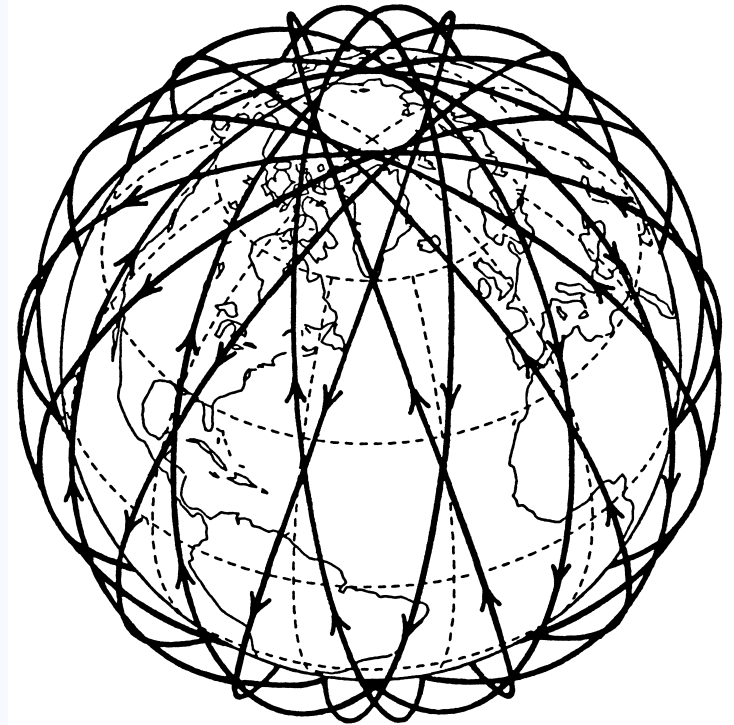


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# The New Synoptic View

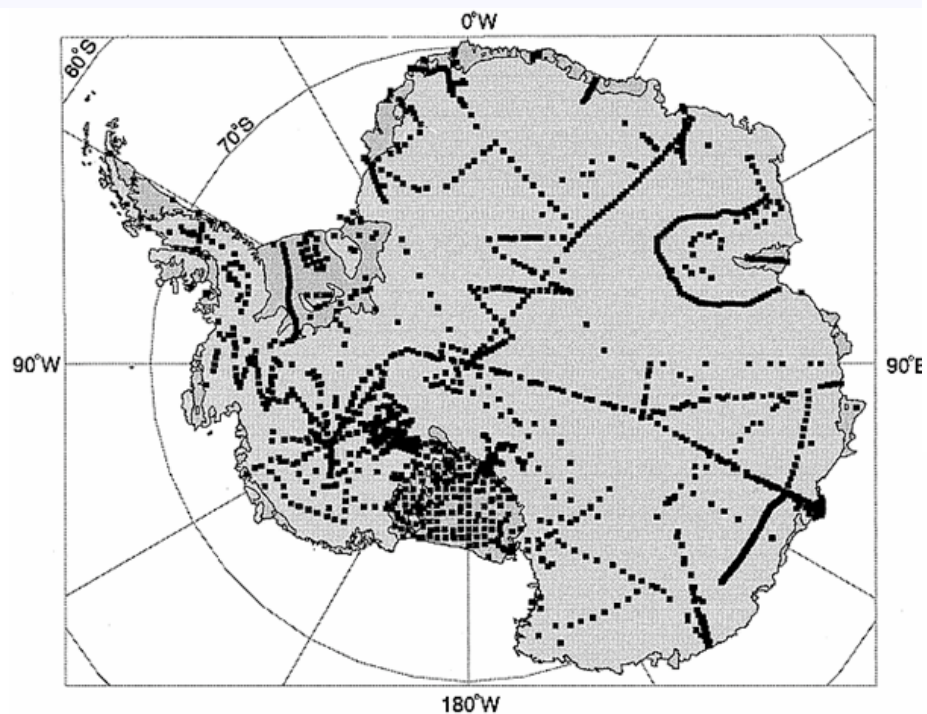


Ground-based weather  
stations as “Truth Sites”

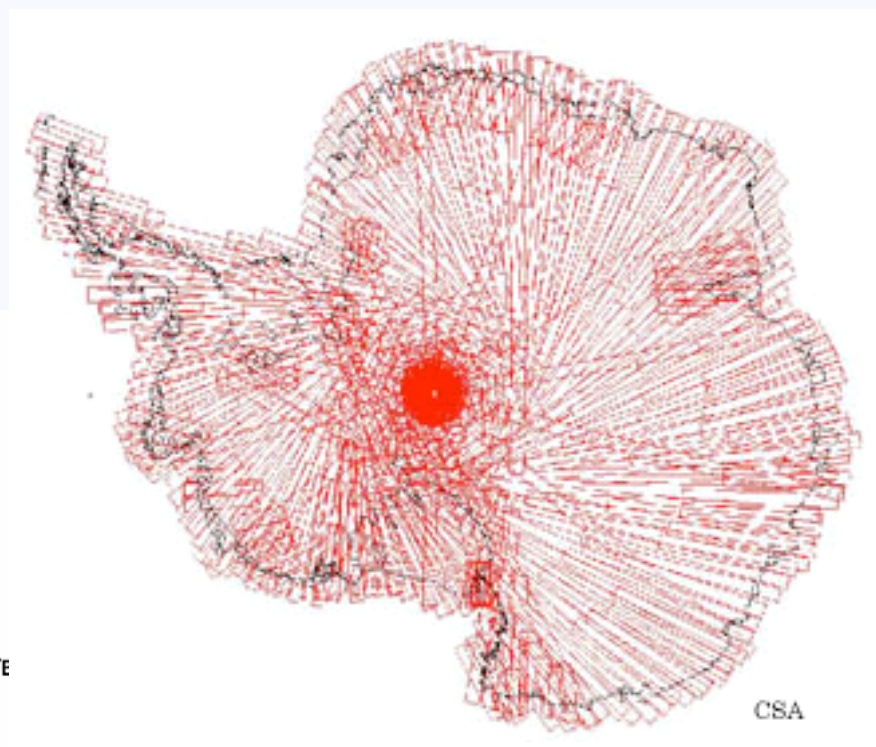


One day's satellite coverage  
“Truth Trajectories”

# Antarctica since the IGY

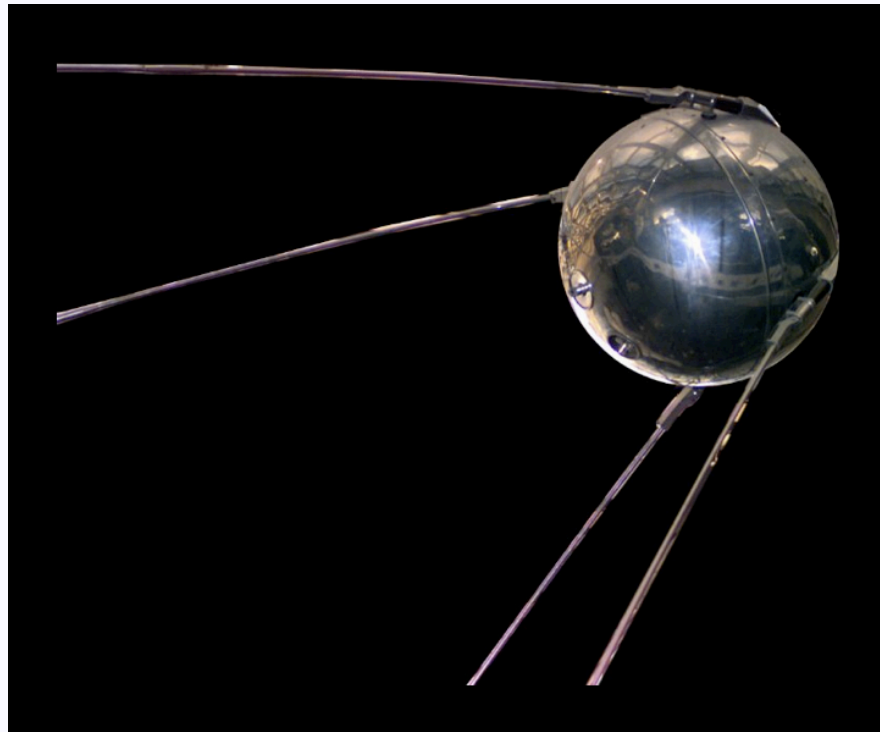


Antarctic surface observations ca. 1958



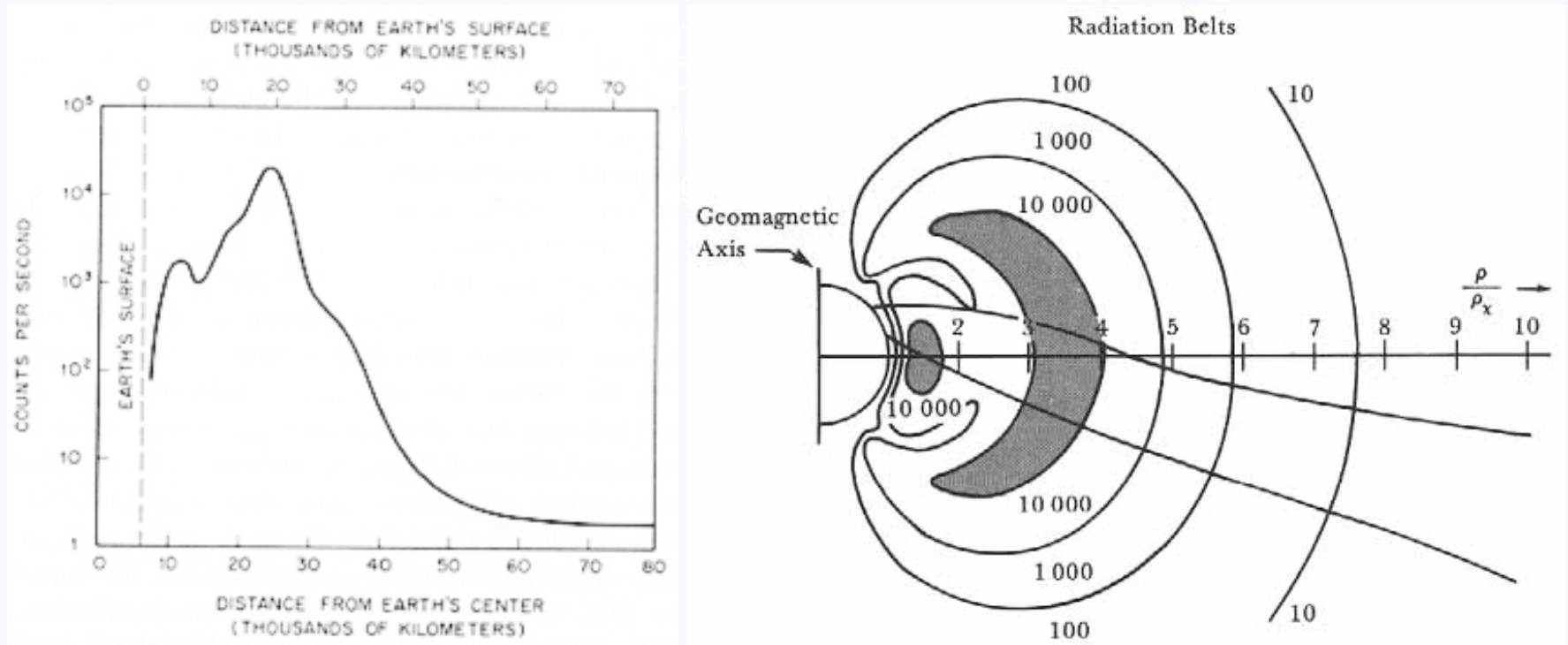
Satellite coverage

# Sputnik 1 (1957)



Although it carried no remote sensing instruments, the orbital decay of the first Earth satellite, Sputnik 1, provided information about the density and dangers of the near-space environment. The operation of its two radio transmitters provided clues regarding the electron density of the ionosphere and indicated that the satellite's pressurized nitrogen compartment had not been punctured by micrometeorites.

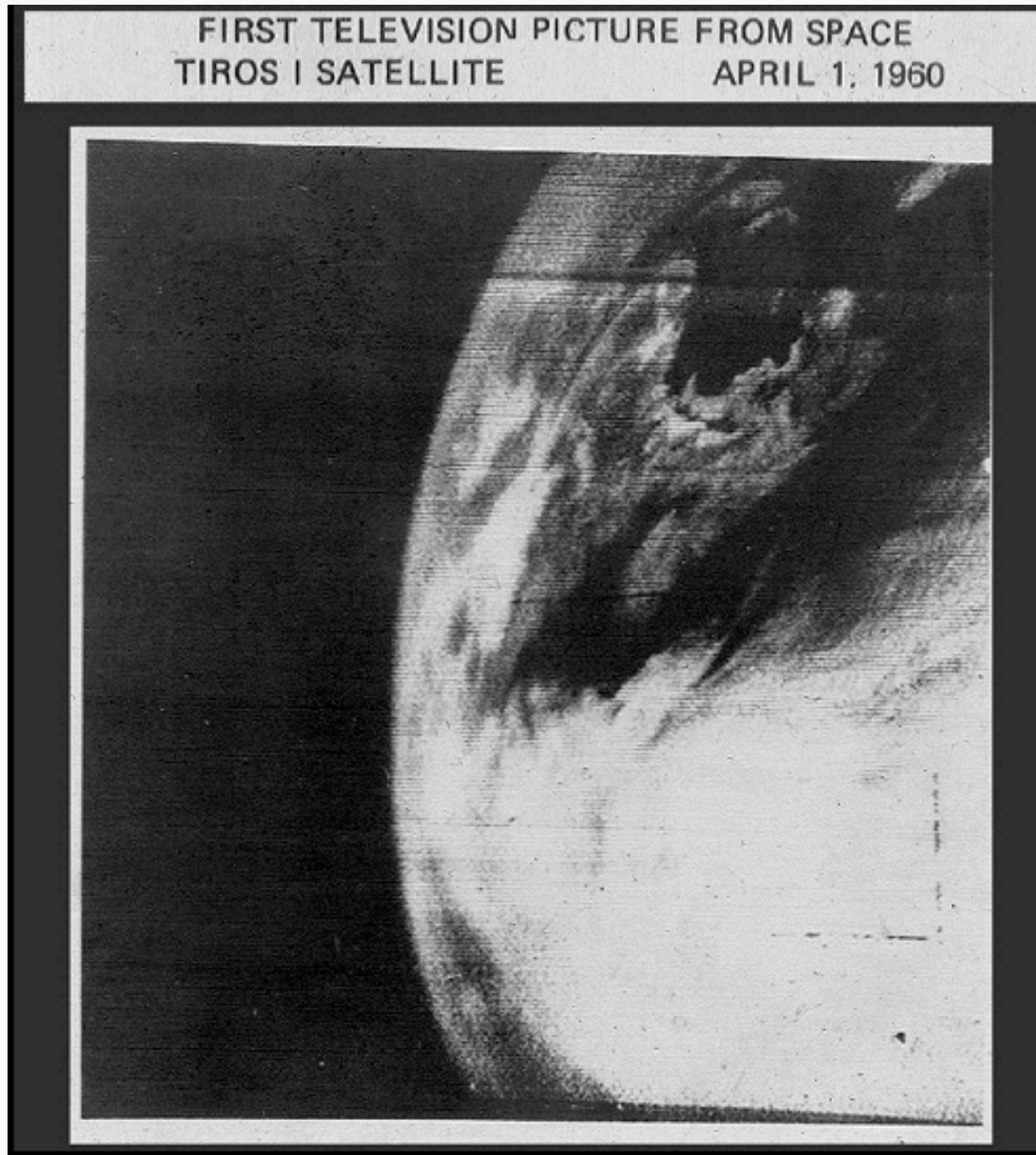
# Van Allen Radiation Belts



## Explorer 6 Earth image 1959



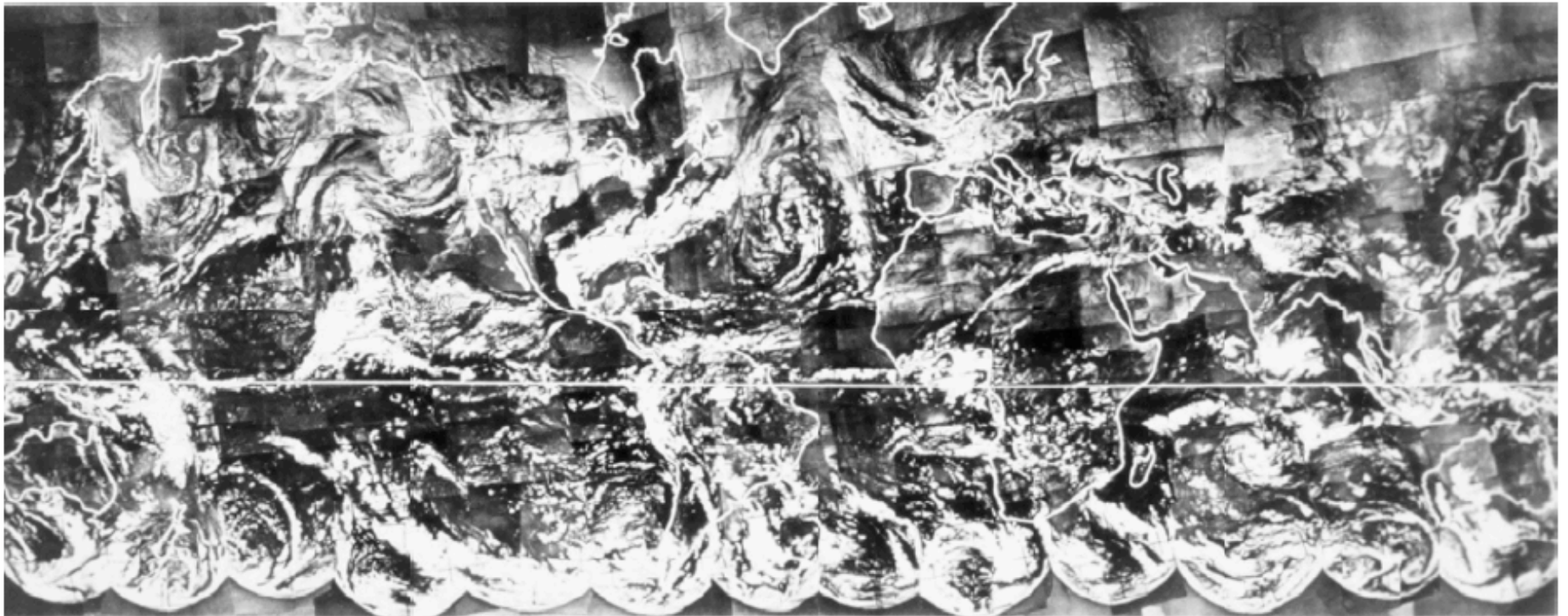
## Planet Earth from TIROS 1: First TV Image



Ability to resolve cloud and surface features.

Served as a “storm patrol”

Possibility of measuring the heat budget of the planet.



**FIGURE 3.3** First complete view of the world's weather, photographed by TIROS 9, February 13, 1965. Image assembled from 450 individual photographs. SOURCE: Publication of the National Oceanic and Atmospheric Administration (NOAA), NOAA Central Library.



**FIGURE 3.4** Example of the hemispheric coverage of a geostationary satellite. Taken by NASA's Applications Technology Satellite 3 (ATS 3) at 1402 UTC on July 21, 1970. Note that Tropical Storm Becky can be seen in the Gulf of Mexico near Florida.  
SOURCE: NOAA Photo Library.

# Measurements of the Earth's Radiation Budget from Satellites During a Five-Year Period. Part I: Extended Time and Space Means

THOMAS H. VONDER HAAR<sup>1</sup> AND VERNER E. SUOMI

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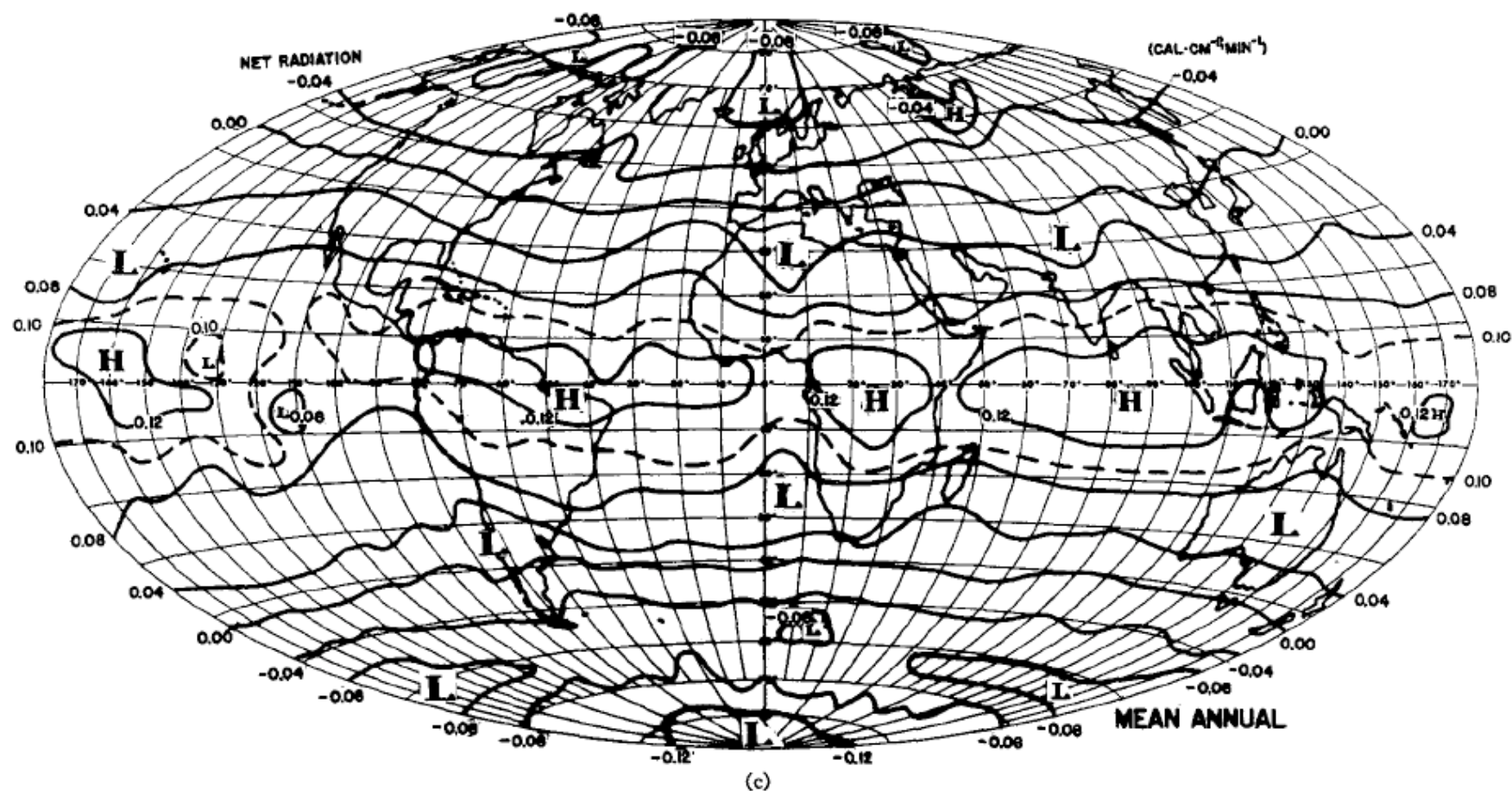
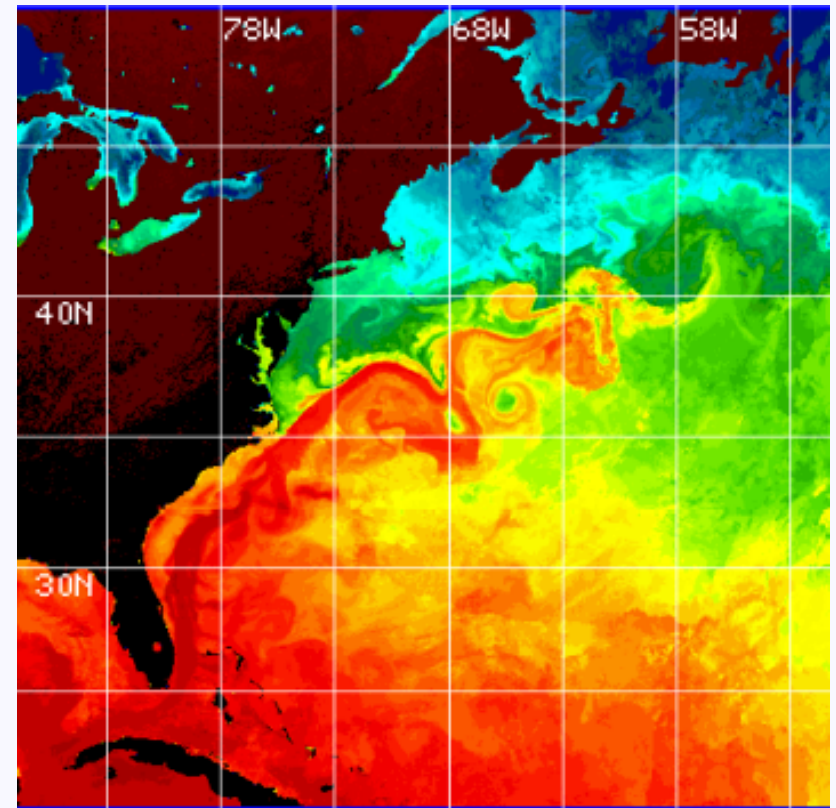
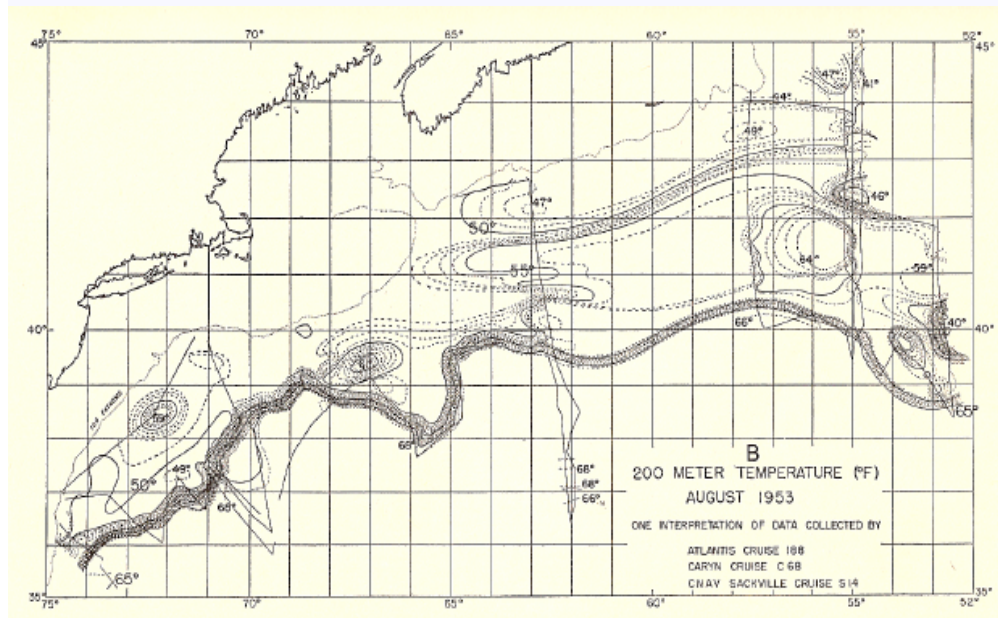


FIG. 4 (continued).

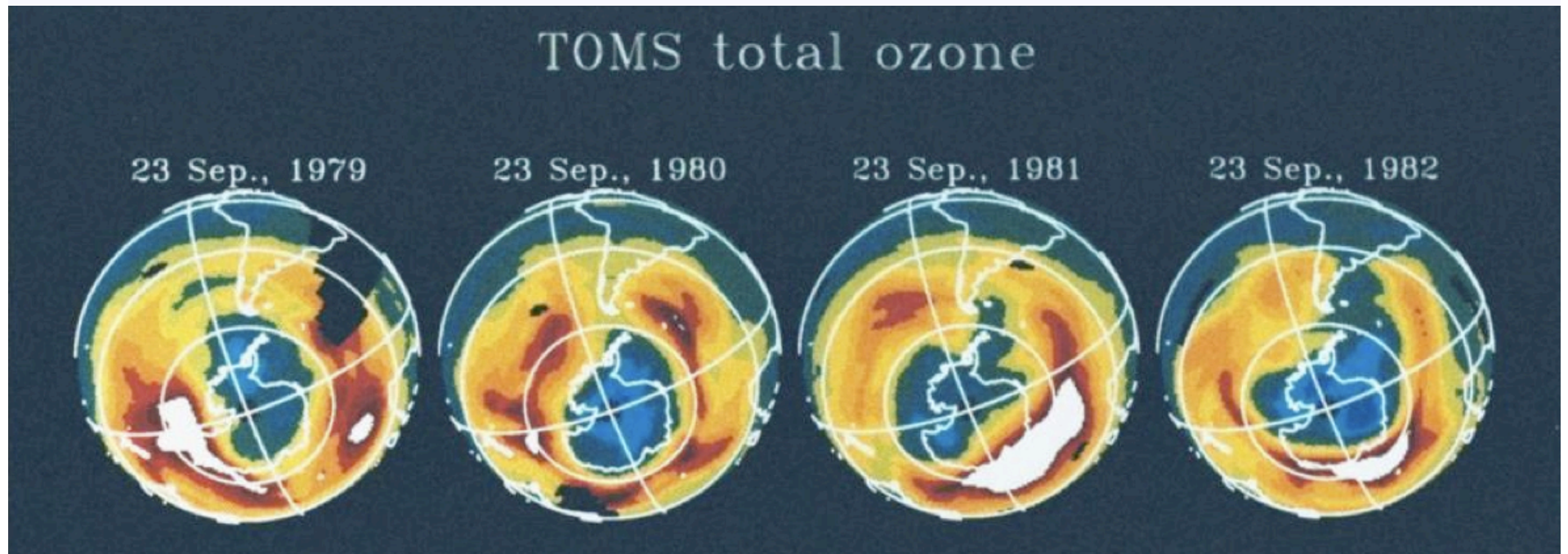
# The Gulf Stream



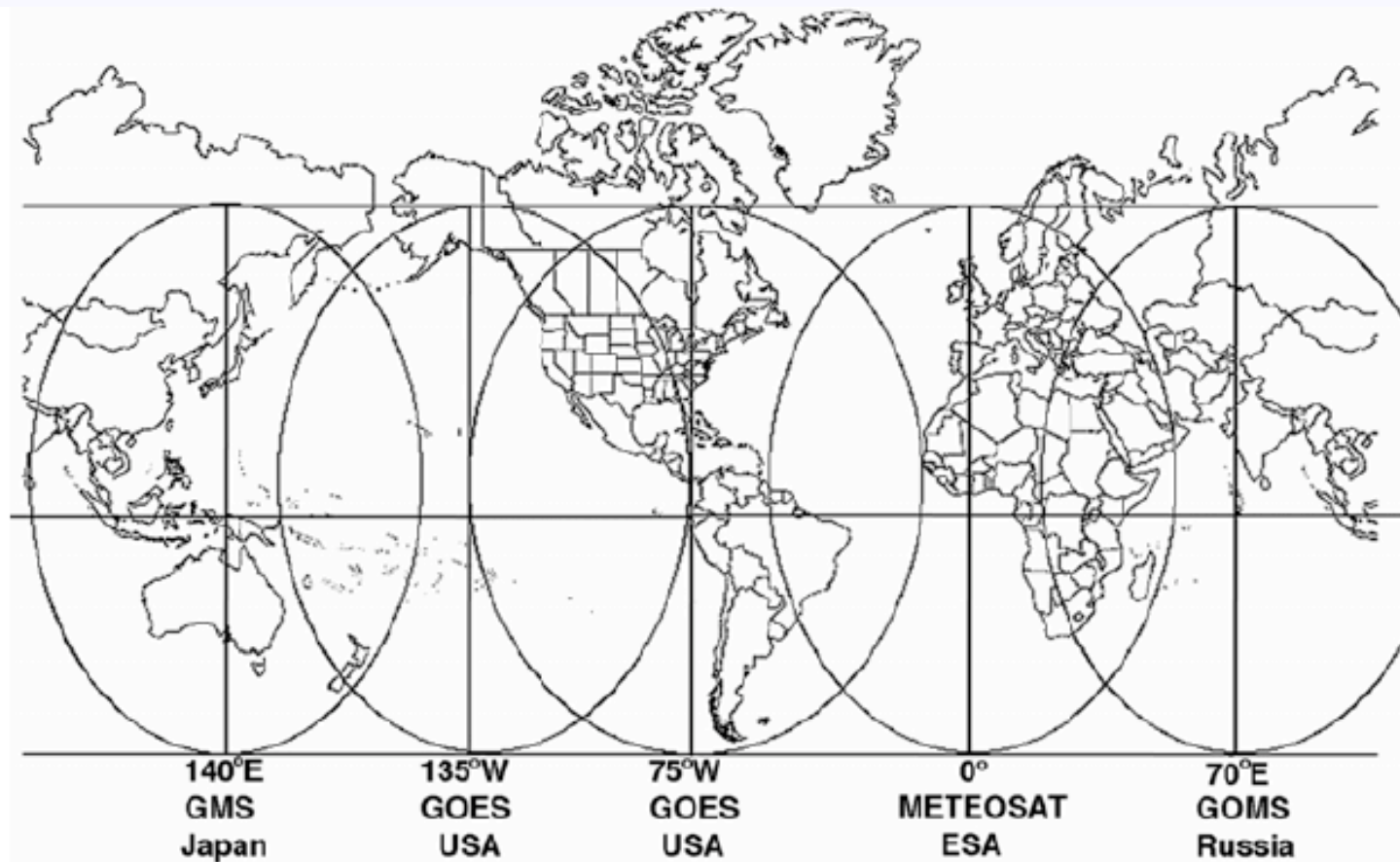
1970s: Single current observations

Stommel 1965: Multiple current hypothesis

# TOMS: Total Ozone 1979-1982

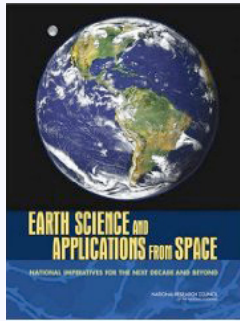


# Global Weather Experiment 1978-1979



**FIGURE 2.7** During the GWE, five international geostationary satellites supported global observations of cloud-tracked winds. SOURCE: NOAA (1984).

## Decadal Survey (2007)

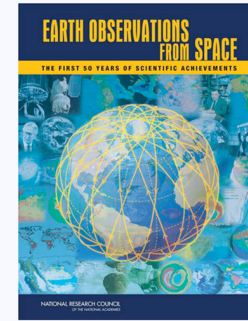


### **Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (2007)**

(Decadal Survey) generated consensus recommendations from the Earth and environmental science and applications community regarding science priorities, opportunities afforded by new measurement types and new vantage points, and a systems approach to space-based and ancillary observations that encompasses the research programs of NASA and the related operational programs of NOAA.

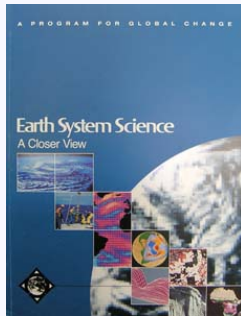
**THE NATIONAL ACADEMIES**  
*Advisers to the Nation on Science, Engineering, and Medicine*

## Historical Study (2008)

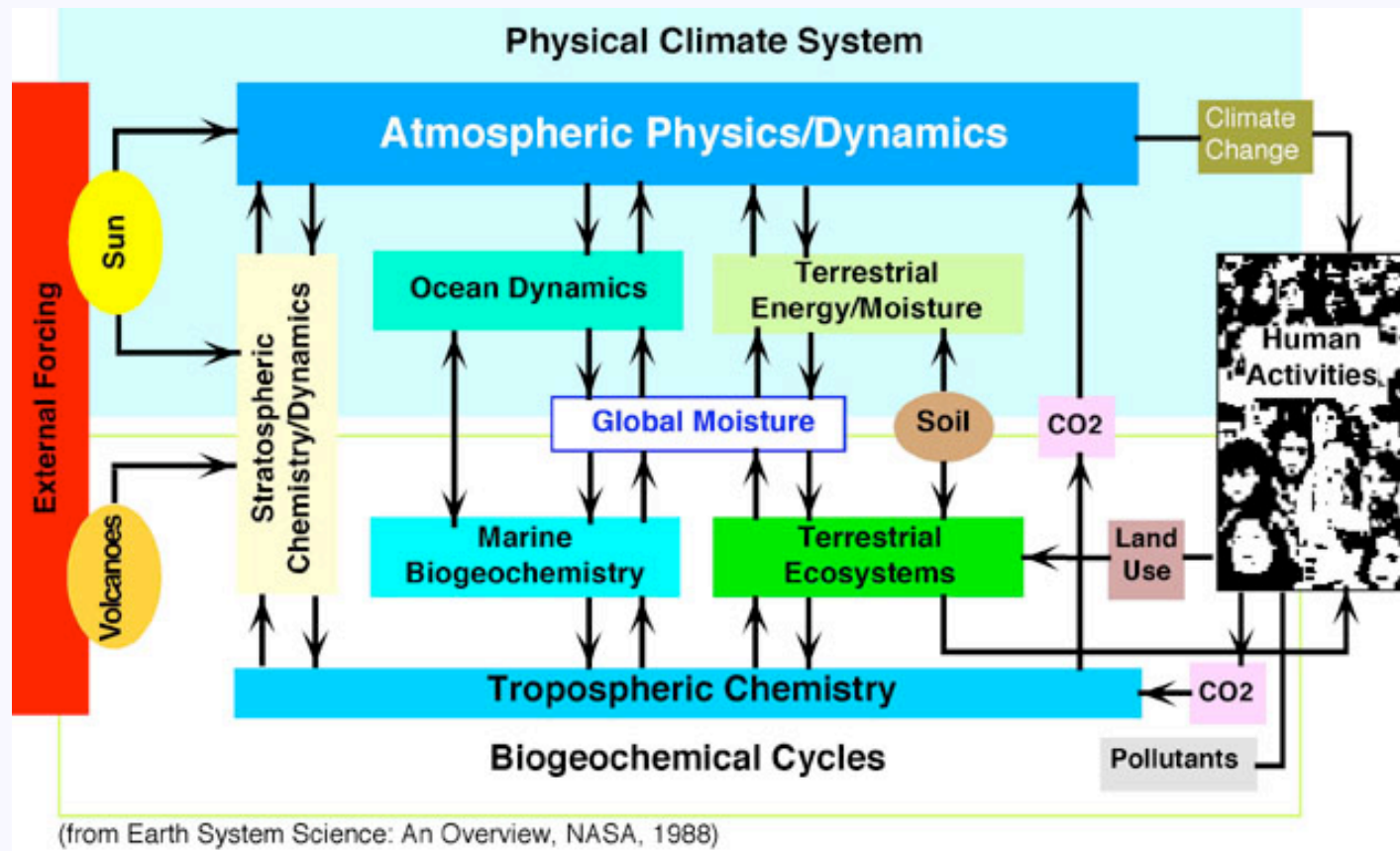


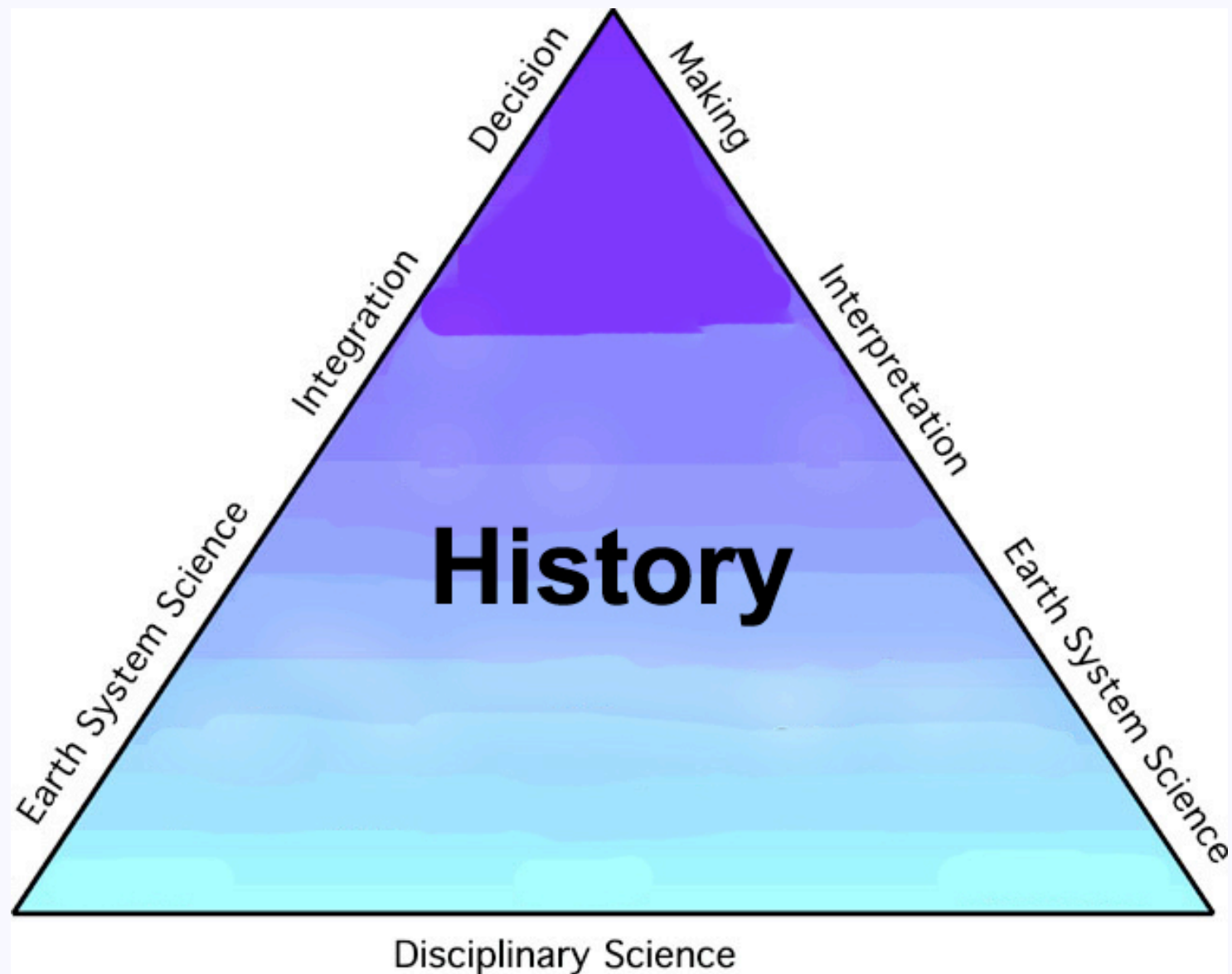
### **Earth Observations from Space: The First 50 Years of Scientific Achievements (2008)**

(Historical Study) documented how satellite observations have uniquely contributed to scientific understanding of the atmosphere, ocean, land, biosphere, and cryosphere. It addressed Earth system predictability and societal implications and benefits of satellite data.



# Earth System Science: A Closer View (1988)







**Space technology affords new opportunities for scientific observation and experiment, which will add to our knowledge and understanding of the earth — PSAC, 1958.**



<b>Cost of Earth observations:</b>	<b>\$Billions</b>
<b>Value of understanding your home planet:</b>	<b>Priceless!</b>